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Tallgrass Prairie Center: Soil Legacy Effects of Prairie Biomass Feedstocks with Different Diversity

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Background /Previous Research

- A high-diversity mixture of native prairie vegetation could be an ideal biomass feedstock for marginal farmland in the Midwestern United States [1].
- Previous research suggests that a high-diversity biomass feedstock should require less fertilizer than a low-diversity feedstock [1] because of complementarity effects (e.g., greater niche differentiation and legume enhancement of soil N) [2].
- Over the past seven years, we have studied the ecosystem services provided by prairie biomass feedstocks with different diversity (1, 5, 16, and 32 species) at Cedar River Ecological Research Site (CRERS) in Black Hawk County, Iowa, U.S.A.
- Research at CRERS has shown that the 5-species feedstock is less productive than the other three feedstocks (Fig. 1), that soil nutrient depletion has been highest in the 5-species feedstock, and that switchgrass plants in the 5-species feedstock have lower photosynthetic capacity than switchgrass plants in the other three feedstocks (Fig. 2).

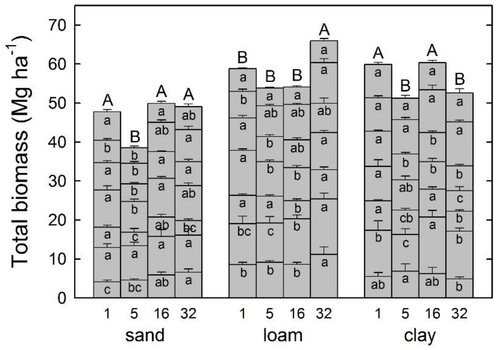

Fig. 1: Total productivity (2010 – 2016) was lower in the 5-species feedstock than the other feedstocks at CRERS. Data published in [3,4].

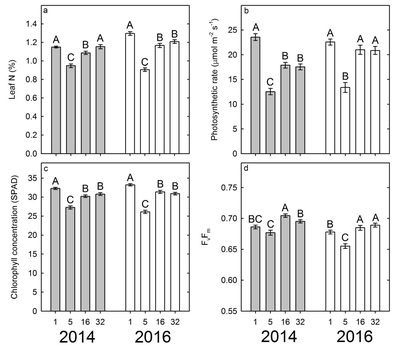

Fig. 2: Switchgrass plants in the 5-species feedstock display the lowest leaf N, photosynthetic rate, chlorophyll content, and leaf florescence (F_vF_m). Data published in [5].

- These previous results suggest that N stress might be the reason for the low productivity of the 5-species feedstock.
- In this study, we compare the growth of switchgrass plants in soil collected from each feedstock to test this hypothesis.
- We hypothesized that plants would produce less biomass in soil collected from the 5-species feedstock than in soil collected from the other three feedstocks.

Methods

Study Site:

- This study was conducted in the UNI greenhouse using soil from CRERS. There are three soil types and four feedstocks: 1-species (a *Panicum virgatum* (switchgrass) monoculture, 5-species (a mixture of C_4 grasses), 16-species (a mixture of C_3 and C_4 grasses, forbs, and legumes), and 32-species (a mixture of C_3 and C_4 grasses, forbs, legumes, and sedges) at CRERS (Fig. 3).

Design:

- We grew 40 switchgrass plants in field soil collected from each feedstock (40 × 4 =160 plants). Field soil was collected from three randomly selected positions in each plot on the sand soil on June 8 2016. Soil samples collected from the same feedstock were combined, pushed through a 10mm sieve, homogenized, and placed into 160 - 1L conetainers. Pre-germinated seeds were sown on June 9 2016.
- Plants that had not emerged by June 13 2016 were excluded from analyses.
- On September 1 2016, we harvested aboveground and belowground plant biomass. The tissue was dried to a constant mass and weighed.
- We compared plant growth between feedstock soil sources using one-way ANOVA with soil source as a fixed factor.

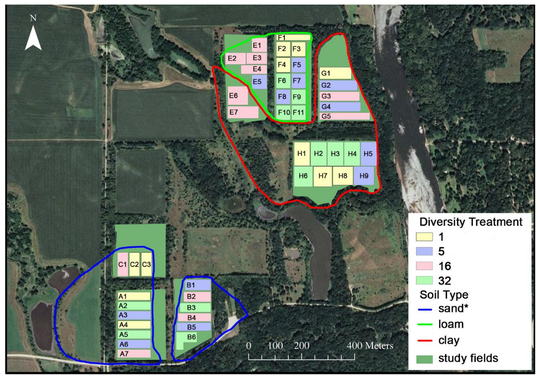

Fig. 3: Map of Cedar River Ecological Research Site (CRERS).

Results

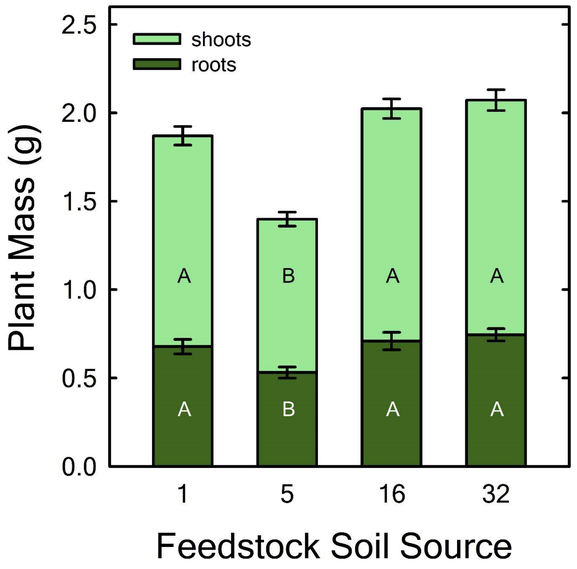

Fig. 4: Aboveground and belowground biomass of switchgrass plants grown in field soil collected from the four feedstocks at CRERS. Letters indicate significant differences in aboveground and belowground biomass between feedstock soil sources.

- Switchgrass plants grown in soil collected from the 5-species feedstock produced significantly less aboveground and belowground biomass than switchgrass plants grown in soil collected from the other feedstocks.
- Plants grown in soil collected from the 1-, 16-, and 32-species feedstocks produced the same amount of aboveground and belowground biomass.
- Percent emergence was not significantly lower in soil from the 5-species feedstocks than soil from other feedstocks (data not shown).

Research plots at CRERS

Conclusions

- Our results support the hypothesis that the low productivity of the 5-species feedstock at CRERS is due to higher N stress.
- Reduced plant growth in this feedstock soil source, relative to the high-diversity feedstock soil sources, was likely driven by the absence of legumes. Legumes form symbiotic associations with soil microbial organisms, which enhances soil N and increases plant performance [6].
- The absence of N stress in the 1-species feedstock could be because switchgrass has lower N uptake and higher root length density than other C_4 grasses [7], resulting in slower soil N depletion.
- In summary, our results suggest that a 5-species C_4 grass mixture is not an ideal candidate feedstock for biomass production because it depletes soil N at a faster rate than the other three feedstocks at CRERS.

Alec Glidden (left) and MJ Lashbrook (right) surveying a CRP field

Acknowledgements

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